FORECASTING PRICES OF AGRICULTURAL PRODUCTS

(Preliminary material for use of members of class in Price Analysis, United States Department of Agricultural Graduate School. Not for general distribution.)

Prices of farm products can be forecasted only in the same way that anything else may be foretold, and that is by judging the future from the past. The elements of the situation are (1) knowledge as the economic factors or forces which influence the price; (2) knowledge as to the extent to which changes in each of these forces cause the price to change; (3) knowledge of how closely changes in the price are dependent upon those particular factors, and how far upon unknown or accidental factors; and finally (4) facts as to the present or prospective value of each of the factors for the period for which the price is to be forecasted.

The knowledge called for in the first three subdivisions can be gained only by studying the past variations in the price of the commodity, and discovering what factor or factors have appeared to be responsible, for those changes. The change in price accompanying a change in each one of these factors is then determined by appropriate statistical measures. The portion of the price changes which cannot be explained by variations in these factors is also determined, to serve as an indication as to the minimum average error which may be expected when prices are estimated from these same factors in the future. Then when the value of each of these factors is known for some new period, the analysis of previous experience serves to indicate the price that is most likely to prevail during that new period - if economic conditions have continued the same as they were during the period studied.

Forecasting the Price for a Crop Season

The simplest case is to forecast for the marketing season the average price of some annual crop after the supply is once known. Potatoes may be used as an illustration. After the size of the American crop is fairly well established, as for example by the November 1 crop estimates, the average price expected to prevail through the remainder of the season may be forecasted with reference to the size of crop.

For crops such as corn, cotton, or wheat, the carry-over from the previous season may have to be considered, as well as the new crop. But in the case of perishable products, or of a semi-perishable product like potatoes, carry-over is not a factor, (in the United States this is literally true only of late or main crop potatoes - prices of early potatoes are affected by stocks of late potatoes from the preceding crop.)

The basic data for the study of the annual price of potatoes are as follows:

Year	U. S. Crop	Average farm price for crop season July to June	Index of wholesale price level (1926 = 100)
	Million bushels	Cents per bushel	(Av. July to June)
1908	302	82	65
1909	395	58	71
1910	349	61	66
1911	293	100	67
1912	421	56	70
1913	332	71	69
1921	351 1/	121	94
1922	434 1/	74	101
1923	392 1/	94	98
1924	422 1/	77	101
1925	323	184	103
1926	354	141	97
1927	403	108	97
1928	463	61	98

1/ Data for 1921 to 1923 adjusted for shift of crop estimates to new census base in 1924.

The years during the war period and the inflation and deflation following are omitted, as the extreme instability of prices in those years upset most of the usual relationships.

It is evident that potato prices during the pre-war period and the postwar period are not directly comparable, since the price level has been roughly fifty per cent higher during the latter period. The price level was on approximately one level during the period 1905 to 1914, and on another level during the later period. The relation of supply to price may therefore be determined separately for each period. Figure 1 shows the data plotted. Each dot is numbered to indicate the observation it represents. These observations fall into two groups, one for the pre-war years, and another for the post-war years. Averaging together years with about the same size crop, the following averages are secured:

Production	Average crops	Average price -
Pre-war years	Million bushels -	Cents per bushel
290 - 320 million bushels	292.5	97
320 - 350 " "	340.5	66
350 million bushels and over	408.0	57
Post-war years		
320 - 370 million bushels	342.7	148.7
370 - 420 " "	397.5	101.0
420 million bushels and over	428	75.5

The averages are plotted on figure 1, and connected by dotted lines, giving the irregular lines shown in the figure. Then the curves shown are drawn free-hand, giving an approximate indication of the average price for the season for a crop of each given size. Departures from the curves are most marked for 1921 and 1927. Even then, the differences are only twelve and fourteen cents, respectively. The average errors are under one and seven cents for both the pre-war and postwar curves, respectively, indicating how closely the price for the season is related to supply alone.

It should be noted that in 1921 when the price level was below the average for the period, the actual price fell below that indicated by the curve. A more careful allowance for differences in price level can be made by first adjusting each year's price for the differences in price level, and then comparing the years on the basis of the adjusted prices. While more elaborate adjustments may be used the simplest adjustment may be made by assuming that each percentage change in price level tends to cause an exactly corresponding percentage change in price. Thus with a price index for 1926 = 100, the price may be adjusted to the purchasing power of money in 1926 by stating the price for each year as follows:

$$\text{Adjusted price} = \frac{100 \text{ actual price}}{\text{index of price level}}$$

The following statement shows the computations for the data previously presented.

Year	U. S. Crop	Index of price-level 1926 - 100	Acreage farm price for season	
			Actual price	Adjusted price
	Million bushels		Cents per bu.	Cents per bu.
1908	302	65	82	126
1909	395	71	58	82
1910	349	66	61	92
1911	293	67	100	149
1912	421	70	56	80
1913	332	69	71	101
1921	351	94	121	129
1922	434	101	74	73
1923	392	98	94	96
1924	422	101	77	76
1925	323	103	184	179
1926	354	97	141	145
1927	403	97	108	111

The next step is to plot the size of crop and the adjusted price, as shown by the dots in Figure 2. Even after making the adjustment, the observations for the pre-war and post-war periods fall on different levels. The observations are therefore grouped as before, and separate curves drawn in for each. These curves now indicate the average price for the season for a crop of any given size, and may therefore be called curves of supply and price. The curve for the post-war years is materially steeper than for the pre-war, indicating that the demand, as reflected in farm prices, has become less elastic.

Once the crop for any year is known, its average price may be forecasted from the curve of supply and price. Thus in October, 1928, the crop was estimated at 464 million bushels. The curve indicates a price of about 56 cents per bushel. (The exact price is not certain, since this is a larger crop than any of the previous observations.) Actually, the price for the season averaged 61 cents, or adjusting for the price index of 98, an average of 62 cents. The actual price was thus within 6 cents of the forecasted price. During the post-war period from 1921 to 1927, the prices estimated from the curve in Figure 2, came within 7 cents of the true prices, on the average, so the agreement in 1928 is within what would have been expected. The extent to which differences in potato prices during this period may be explained by differences in supplies may be shown by reading the estimated prices from the curves in Figure 2, to correspond to the supplies of each year, and plotting them in comparison with the actual prices for the season. This comparison is shown in Figure 3, where both actual and estimated prices are given in terms of the 1926 level of prices.

The fact that during the post-war period the estimated prices were high in 3 out of the first 4 years, and were low in the last 4 years, suggests that there has been an upward movement in demand during this period, possibly due to the growth of population. Methods of treating this shift in demand are taken up in the next section, and therefore will not be considered here. However, it should be noted that the accuracy of the forecast could be improved by taking the change also into account.

In the case of non-perishable crops where the carry-over may be a significent item, carry-over must be included in the supply considered. In the case of cotton, for example, stocks of American cotton throughout the world as well as crops in the United States, influence the price for the season. The pertinent data for cotton for recent years are as follows:

Year	U. S. Crop	World carry-over of American cotton 1/	Crop plus carry-over	Price for season 2/	Price index	Adjusted price
	Million bales	Million bales	Million bales	Cents per lb		Cents per lb.
1921-22	7.95	9.34	17.29	17.91	95.7	18.72
1922-23	9.76	5.30	15.06	24.58	103.6	23.73
1923-24	10.14	3.30	13.44	30.97	100.0	30.97
1924-25	13.63	2.99	16.62	23.84	103.9	22.95
1925-26	16.10	3.57	19.67	20.32	103.3	19.67
1926-27	17.98	5.73	23.71	13.78	97.8	14.09
1927-28	12.96	7.80	20.76	20.11	99.5	20.20
1928-29	14.37	5.08	19.45	18.89	95.0	19.88

1/ As of Aug. 1.
2/ Middling cotton at New Orleans, Aug. to July, weighted by average monthly marketings.

After adjusting the price for differences in price level, the next step is to plot the prices and supply as indicated in the upper portion of Figure 4. The general tendency for a lower price with a larger supply is quite marked. It is also noticeable that there was a tendency for demand to increase during this period - with about the same supply, prices were much higher in '24 than in '21, and with a larger supply in '27 than '25, prices were slightly higher. Selecting 1924 as the middle year of the period, a curve may be drawn as indicated, to pass through 1924, somewhat above the earlier years, and somewhat below the subsequent years, as a first approximation to the curve of supply and price.

The departure of the price each year from the price shown by the curve for the same supply may then be measured graphically, and plotted as shown in the lower portion of Figure 4. The dots here indicate a fairly regular upward trend in demand so a straight line is fitted through the observations to indicate this trend. The original prices may now be corrected to eliminate this trend factor, and to put them all on the basis of the level of demand in 1924. To do this 3.3 cents is added to the price for 1921, 2.2 cents for 1922, and 1.1 cents for 1923. Correspondingly, 1.1 cents is subtracted from the 1925 price, 2.2 cents from the 1926, and 3.3 cents from the 1927. The prices thus adjusted are also shown in the upper portion of Figure 4, as hollow circles. These corrected values indicate that the curve in the upper portion would fit more accurately if straightened out somewhat in the lower portion and if curved more sharply in the upper. These changes are therefore made, yielding the revised curve indicated by the dotted line.

Figure 4 appears to offer almost a complete explanation of the yearly changes in cotton prices over 7 years. The largest departure between the actual and the estimated price during this period, in 1924, is only half a cent, and the correlation between the actual and the estimated prices is almost perfect.

With such a small number of observations to base the analysis upon, however, the results are still open to doubt. This is strikingly brought out when the relations shown in Figure 4 are used to work out the expected average price for the 1928 crop. With a supply of 19.45 million bales, the revised curve in the upper portion of the chart would have indicated a price of 18.8 cents, to which the growing demand, indicated in the lower portion of the chart, would have added 4.4 cents more. The expected average price for the season would therefore have been 23.2 cents. Actually, the price for the season averaged only 18.9 cents, which with the average price-level of 95.0, meant 19.9 cents in terms of adjusted prices. For this particular year, then, the price forecast would have missed by over 3 cents - six times as great an error as in any of the 7 years on which the curves were based. Apparently some new factor, which had not been of outstanding importance during the prior years, entered the situation. It may have been the crop of Indian or of Chinese cotton, which ordinarily is regarded as non-competitive; or it may have been the effect of the heavy consumption during the two years prior to 1928, which may have tended to saturate the consuming markets. At any rate, the previous explanation failed to work so well. Further study, and possibly more years' experience, will be necessary to determine whether additional factors are involved or whether there has been a real though sudden shift in the level of world demand.

Forecasting the Seasonal Variation in Prices.

In addition to studies of the relation of supplies to average price, as illustrated very simply in the cases of potatoes and of cotton, the movements of prices through the season may be studied. One way of doing this is to consider the differences in the seasonal movement of prices in years of crops of various sizes. In Figure 5, for example, are shown the monthly farm prices of potatoes, expressed

as a percentage of the average for the season from July through June - the same average as used in the previous study of the influence of size of crop on average price. The price movement during years of small crops is shown in the upper portion of the chart; during years of moderate crops, in the central portion of the chart, and in years of large crops, in the lower portion of the chart. It is evident that there was some tendency toward similar seasonal movements in each of these groups of years; prices tending to rise through the season with small crops and to fall through most of the season with large crops. When the average price for each type of season is worked out, the averages indicated by the heavy lines are obtained. The difference in the average seasonal price movement between different seasons, as shown by these lines of averages is quite marked. 1/

Farm price of potatoes by months

Year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Weighted average for entire season
1908	80.3	76.4	72.0	69.9	71.3	72.6	76.6	83.2	82.0
1909	78.3	67.9	61.0	56.0	55.0	56.1	55.4	51.0	57.9
1910	68.9	70.4	61.8	55.7	54.9	54.6	55.2	55.4	61.3
1911	124.8	101.0	82.3	78.1	82.2	89.4	98.2	109.6	99.6
1912	75.3	58.0	48.3	48.0	50.6	51.8	52.6	51.2	55.6
1913	72.2	74.6	71.8	69.2	68.6	69.0	70.2	70.4	70.6
1921	152.8	153.1	130.6	116.8	109.4	112.0	116.6	115.7	121.3
1922	101.4	73.8	66.2	60.5	58.8	62.0	64.2	68.6	73.9
1923	120.8	109.6	91.4	82.5	81.5	86.4	88.1	87.8	94.2
1924	111.3	81.0	68.8	63.5	64.1	70.2	72.3	71.4	76.5
1925	155.4	121.1	125.6	198.4	201.5	220.5	226.0	225.6	183.5
1926	140.5	130.6	123.4	141.3	137.0	139.1	134.1	127.0	140.3
1927	146.3	107.4	97.9	95.4	94.1	93.6	96.2	113.2	108.4
1928	73.1	64.8	58.0	56.9	57.7	58.9	59.5	58.4	61.0

Monthly price in percent of average for each season

Year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1908	98.5	93.2	87.8	85.2	87.0	88.5	93.4	101.5
1909	135.2	117.3	105.4	96.7	95.0	96.9	95.7	88.1
1910	112.4	114.8	100.8	90.9	89.6	89.1	90.0	90.4
1911	125.3	101.4	82.6	78.4	82.5	89.8	98.6	110.0
1912	136.3	104.3	86.9	86.3	91.0	93.2	94.6	92.1
1913	102.3	105.7	101.7	98.0	97.2	97.7	99.4	99.7
1921	126.0	126.2	107.7	96.3	90.2	92.3	96.1	95.4
1922	137.2	106.6	89.6	81.9	79.6	83.9	86.9	92.8
1923	128.2	116.3	97.0	87.6	86.5	91.7	93.5	93.2
1924	145.5	105.9	89.9	83.0	83.8	91.8	94.5	93.3
1925	84.7	66.0	68.4	108.1	109.8	120.2	123.2	122.9
1926	99.8	92.8	89.8	100.4	97.3	98.8	95.2	90.2
1927	135.0	99.1	90.3	88.0	86.8	86.3	88.7	104.4
1928	119.8	106.2	95.1	93.3	94.6	96.6	97.5	95.7

1/ I am indebted to Louis H. Bean of the Bureau of Agricultural Economics, United States Department of Agriculture for the use of these data, taken from a manuscript on potato prices now being prepared.

By combining the estimate based on Figure 2 with the average seasonal movements shown in Figure 5, the price through the marketing season may be estimated for any particular set of circumstances. In 1928, for example, with a crop of 463 million bushels, an average price for the season of 56 cents was indicated; while the seasonal movement of a large crop year might have been anticipated. Multiplying the estimated average price by the average seasonal variation for large-crop years gives estimated monthly prices as shown in Fig. 6. The actual monthly prices, also shown in Figure 6, fell fairly near the estimated prices through the season, indicating that in this case the relations continued to hold much as they had held in earlier years.

The Influence of Price Upon Consumption.

The analyses to this point have all studied the effect of total supplies upon the seasons price, and have not yielded a true demand curve. In addition to the price for a given supply, the question may be asked: What will be the most probable consumption for a given price? To answer this it is necessary to determine the demand curve. The necessary data to determine this for cotton are shown in the following statement.

Year	Adjusted price for season	World disappearance of American cotton
	Cents per pound	Million bales
1921-22	18.72	11.99
1922-23	23.73	11.76
1923-24	30.97	10.45
1924-25	22.95	13.05
1925-26	19.67	13.94
1926-27	14.09	15.91
1927-28	20.20	15.68
1928-29		

1/ Supply at beginning of season plus new crop, minus world carry-over at end of season.

The next step is to plot the disappearance against the average price, to see how far price alone has determined consumption; as is shown in Figure 7. The upper portion of this figure shows the same tendency for demand to increase in successive years that was noted in Figure 3, since with about the same prices, consumption was higher in 1925 then in 1921, and higher in 1927 than 1925. The same situation appears in 1922 and 1924. Accordingly a curve is drawn in so as to pass near the central year, 1924, and above the earlier years and below the later years. The deviation of consumption from that shown by this curve for each year's price is then plotted in the lower portion of the figure. A straight-line trend is drawn in, and the previous consumption figures are adjusted for the upward trend, as indicated by the hollow dots. The location of these dots indicates that a slightly convex curve will fit the adjusted observations better than the original curve, so the new curve is drawn in as indicated by the dotted line.

The trend line and the revised curve, together, account entirely for the difference in consumption each year except in 1925 and 1927, missing those years by only about two-tenths of a million bales. The ends of the curve, however, are entirely determined by the single observations for 1926 and 1923, so not much confidence can be placed in its exact shape toward the ends. The consuming demand for cotton, as indicated by the revised curve, has an interesting shape in that very low prices are accompanied by only slight further increases in consumption while very high prices cause more marked decreases in consumption. The very inelastic nature of the demand for cotton is indicated by the fact that a reduction in average price from 26 1/2 cents per pound to 16 cents per pound is required to increase world consumption from 12 million bales a year to 14 million bales. Apparently there has been an annual increase in demand during this period averaging 0.6 million bales a year. Judging from figure 4 a difference of 0.6 million bales would cause a difference of 0.9 cents in the lower portion of the curve, and even more in the upper, so it would appear that most of the upward trend in price for a given supply during this period was due to the upward trend in consuming demand.

The Influence of Price Upon Carry-over

Not all of a non-perishable product is consumed each year, but part of it is carried over into the supply for the next season. In the case of cotton, the price for the previous year is the principal factor influencing the carry-over. The data to determine this relation have already been shown on page 7, all that is necessary being to compare the adjusted price for one year with the carry-over at the beginning of the next year. Figure 8 shows this comparison. Contrary to the case with consumption, the carry-over demand for cotton seems to show practically no upward trend during this period. A single curve is accordingly drawn in to fit all the observations shown; except for departures of about three-quarters of a million bales in 1925, and one-quarter million in 1921, it comes very close to passing through every single observation.

In studies of consumption in the United States alone it has been found that general business activity was reflected in cotton consumption, as well as the price per pound. Figure 8 would indicate, however, that for the world as a whole this effect is largely masked by other factors.

It might be noted that the relation of total supply to price, and the relation of price to quantity taken for consumption and quantity taken for storage, both show essentially the same thing. Thus if we read off the consumption and carry-over for different prices, say for the level of demand in 1924, we have the following results:

Price	Quantity taken for consumption 1/	Quantity taken for carry-over 2/	Total quantity taken	Supply to set that price 3/
14	14.7	7.8	22.5	22.7
18	14.0	5.9	19.9	20.0
22	13.3	4.0	17.3	16.9
26	12.5	3.0	15.5	15.0
30	11.5	2.9	14.4	13.9

1/ From Figure 7, for 1924 level of demand

2/ From Figure 8

3/ From Figure 4

The fourth column shows the total quantity which would be taken at the various prices, for both consumption and carry-over. It is evident from this tabulation that under 22 cents, further reduction in prices have only a slight tendency to increase consumption, while they have a marked tendency to increase carry-over. The increasing elasticity of the demand in the lower part of the total supply - price curve is therefore due primarily to the demand for cotton to store, rather than to consume immediately.

Reading off from Figure 4 the quantities of cotton which would set various average prices (at the 1924 level of demand) the figures given in the last column of the statement are obtained. These values agree in general with those in the previous column, obtained by adding together the two demand curves. This illustrates the statement that the relation of price to consumption and to carry-over, and the relation of supply to price, are essentially different aspects of the same thing. A given price can be obtained for a given supply only because purchasers stand willing to buy just that supply at that price - some to spin it at once, and others to hold it in their mills or warehouses until the next crop is harvested. The demand may be further broken up into the demand in different countries, or for certain types of cotton, or for certain uses. The more the demand is broken up into its component parts, so that one can see all the different elements which are responsible for making the total supplyprice curve just what it is, the more can one understand the variety of forces which are involved in the cotton market.

The differences between the quantities given by the two last lines of the statement above - which in no case exceed one-half a million bales - are due to additional causes which have not been taken into account in studying the influence of supply upon price, or the influence of price upon consumption and carry-over. Examples of these additional factors would be changes in general business activity and in the income of consumers; changes in competition from other textiles, such as silk or rayon; changes in industrial demands for cotton; and changes in economic conditions, or in cotton production, in countries such as India and China, which are great users of cotton fabrics. The departures from the trends and curves in figures 3 to 5 indicate that not all the variation has been explained. Some of the residual variation may be due to factors such as these mentioned. Even some of the trend lines themselves may reflect some of these demand factors, such as European recovery from the war depression and the changing customs in Oriental countires. When more years are available for analysis, and more specific information is available on these points, it will be possible to establish more definitely the principal demand factors which affect the cotton market.

The Influence of Price Upon Subsequent Production.

Since farmers - and producers of many other products as well - tend to respond to favorable prices by increasing production, and to unfavorable prices by decreasing production, it is frequently possible to forecast fairly closely the changes in acres of crops or in numbers of livestock which are likely to take place in response to a given price situation. The response can most readily be measured for those agricultural products where a definite time must elapse before the new production is engaged in. In the case of an annual crop like potatoes or cotton, for example, the price received for the previous crop will usually be the most important factor. If there is an important alternative crop, its price may also be concerned. Thus flax acreage in the Dakotas tends to increase when flax has been high and wheat has been cheap; or sweet potato and corn acreage in the Cotton Belt tends to increase following a year of low-priced cotton. Likewise, for livestock the price of the principal feeds must be considered as well as the price of the product. The relation of hog prices to corn prices largely determines changes in hog receipts 18 months to 2 years later; while the relation of milk prices to the cost of dairy feeds has been found to account for changes in production of milk, some taking place in a few months, and some a year or two later.

A simple determination of the influence of price upon subsequent production may be illustrated by cabbage acreage. The following statement shows the necessary data. 2/

2/ This illustration is taken from the article by Louis H. Bean, "The Farmers' Response to Price," Jour. Farm Econ., July, 1929.

Year	Acreage of cabbage	Change in acreage from previous year	Average price received by cabbage growers	Index of farm prices of all products 1/	Deflated cabbage prices
	thousand acres	thousand acres	dollars per ton	1927 = 100	dollars per ton
1919	96.2		25.48	159	16.0
1920	123.8	+ 27.6	17.90	110	16.3
1921	104.6	- 19.2	24.60	86	28.6
1922	133.8	+ 29.2	12.20	94	13.0
1923	104.9	- 28.9	22.27	96	23.2
1924	119.1	+ 14.2	16.50	103	16.0
1925	120.0	+ 0.9	17.63	104	17.0
1926	129.3	+ 9.3	17.79	93	19.1
1927	143.8	+ 14.5	15.97	100	16.0
1928	136.8	- 7.0	24.04	98	24.5

1/ Average for crop season.

Here the average farm price of cabbage for the commercial areas in the United States is considered, and the acreage for those areas. The price of cabbage is first adjusted by dividing it by the index of the price of all farm products, to show the changes in cabbage prices as compared with the price of other products of the farm as a whole. The acreage planted is expressed as a change from the acreage of the preceding year. This way of expressing the acreage has been found to yield the best results in many studies of changes in farm production, since the farmer always plans his next year's business with regard to what he has done the year before. In general, it has been found that there are marked limits to the amount of change which farmers will make in any given year, but that given continued high prices or low prices, they will continue to make those changes over a series of years.

The data worked out in the preceding statement may now be assembled in the following form:

Year	Deflated cabbage price: Preceding year	Deflated cabbage price: 2nd preceding year	Change in acreage from previous year
	dollars per ton	dollars per ton	thousand acres
1921	16.3	16.0	-19.2
1922	28.6	16.3	+29.2
1923	13.0	28.6	-28.9
1924	23.2	13.0	+14.2
1925	16.0	23.2	+ 0.9
1926	17.0	16.0	+ 9.3
1927	19.1	17.0	+14.5
1928	16.0	19.1	- 7.0

The price for the preceding year 1920, say, is placed on the same line as the change in acreage from the preceding year to the current year from 1920 to 1921. The price for the 2nd preceding year, 1919, is also placed on the same line, so that it may be determined whether there is a hang-over effect of the price of two years ago in planning any one years operations. That is, farmers may respond more markedly to a year of high prices which follows a year of high prices, than to a year of high prices which follows a year of low prices. The analysis of these data is shown in Figure 9, carried through just as for the previous analyses. The response of production to price for the preceding year is first approximately determined, by noting the changes for years where the 2nd preceding year's price was about the same. The deviations from this curve are then plotted against the price for the 2nd preceding year, and a curve drawn to pass through them. The deviations from this curve are then plotted as departures from the first curve, which provides a basis for modifying it; and the departures from this adjusted curve, plotted against the first approximate curve for the 2nd year, indicate a slight revision in that curve. 3/

After the final curves have been obtained by carrying this process on until no further changes are indicated, the estimated acreage for any year may be worked out by reading from the two curves the values on the curves corresponding to the values of the two independent factors for each year. The results obtained are shown in the following statement.

Year	Price 1st yr. prec.	Price 2nd yr. prec.	Estimated acreage, in % of year before: From 1st yr. price	From 2nd yr. price	Total estimate	Actual change in acreage
1921	16.3	16.0	-6.0	0	-6.0	-19.2
1922	28.6	16.3	+27.5	+0.5	+28.0	+29.2
1923	13.0	28.6	-41.0	+11.8	-29.2	-28.9
1924	23.2	13.0	+20.3	-6.0	+14.3	+14.2
1925	16.0	23.2	-11.5	+10.5	-1.0	+0.9
1926	17.0	16.0	+ 3.5	0	+3.5	+9.3
1927	19.1	17.0	+13.2	+2.0	+15.2	+14.5
1928	16.0	19.1	-11.5	+5.5	-6.0	-7.0
1929	24.5	16.0	+22.0	0	+22.0	+19.0

It is evident that the estimated acreages agree very closely with the actual acreages. The last line of the table shows the computation carried out for the 1929 acreage, a year which was not included in the analysis by which the curves in Figure 10 were

3/ This method of correlation analysis was developed by Louis H. Bean. See "Application of a Simplified Method of Graphic Curvilinear Correlation, Preliminary Report, U. S. Dept. of Agri., Bur. Agri. Econ. April, 1929.

arrived at. The estimated change for 1929 is for an increase of 22,000 acres, which compares with an actual increase of 10,000 acres indicated by the June crop report. While this is a fairly close forecast, it can not be expected that the curves shown in Figure 5 will continue to be so accurate in forecasting acreages. Only 8 observations were used in determining the relations, and with 2 complex curves to be determined from such a small number of observations, there is no great certainty that the relations obtained are the true relations. While the forecast was about as close for 1929 as for the other years shown in the table, it would be quite possible in other years for the forecast to miss by as much as two or three times the largest difference in any of these few years on which the analysis is based. 4/

While the relation of price to subsequent acreage may thus be worked out for the country as a whole, it may vary widely in different areas. More detailed studies have shown that the response may be much greater in some sections than in others. For example, Bean's studies show that the response of potato acreage to price changes is relatively larger in areas where that is the most important cash crop than is the response in areas where potatoes are only of minor importance as a source of income. In every case, however, it was found that the price has some influence for two years, and the shape of the curves was quite similar to those shown in Figure 9. This consistency of results from different areas increases the significance of the results, and indicates that greater confidence may be placed in these curves than if they had been found in one analysis alone.

In fact, relations similar to those shown in Figure 9 have been found to be true of many farm products, moderately high prices tending to cause a certain increase in acreage or livestock numbers - 5 to 20%, depending on the circumstances - but very high prices tending to cause practically no more increase. This reflects the fact that farming is a relatively stable business, and that while farmers may be able to make a certain amount of increase within one year, the amount they can change is limited, and once they reach that limit they will make but little additonal increase within one year, no matter how high prices may have been the year before.

In livestock, it has been found that the relation of prices to subsequent production will vary from one region to another, depending on the characteristics of farming in each region. Thus in an area where dairy farming prevails, and hogs are kept to utilize the skim milk, a given change in the corn-hog price ratio has but little influence on hog production; while in an area where much corn is sold for cash, and only a few hogs are kept, the same change may have a very material influence on production. 5/

4/ For a discussion of the statistical reliability of correlation results see "The Application of the Theory of Error to Multiple and Curvilinear Correlations", by the present author. Proceedings of the American Statistical Association, March, 1929, pp. 99 - 104.
5/ F. F. Elliott, "Adjusting Hog Production to Market Demand", Univ. of Ill. Agr. Expt. Sta., Bul. 293, 1927. pages 529-532, 565-567.

More Advanced Methods of Analysis.

The examples discussed to this point have illustrated the essential economic relations which must be determined before price forecasts can be made with any degree of confidence. In these examples only the simplest and most elementary methods of analysis have been used. The problems themselves have been selected to show the relationships with the greatest clarity; and the analysis has been restricted to working out the relations in the simplest way, without using such technical expressions as regression equations, correlation coefficients, or standard errors of estimate. Not all problems can be solved so readily; in fact in most cases the relations are less clearly marked than in those which have been considered. In the last example, the influence of two factors - price one year preceding and two years preceding - upon the acreage change was worked out. In many price problems half-a-dozen factors may have a significant effect, instead of merely the two considered here. Furthermore, the influence of factors which change with time, either gradually over a long period, or which recurring more or less regularly from day to day, week to week, or month to month, may have to be allowed for. In some cases it may be necessary to measure the composite influence of these forces which vary with the calendar by first determining the secular trend and average (or changing) seasonal variation in the several series, and then eliminating them from the data before determining the relations of the series to each other. There is always danger, however, that this process may impute to the influence of factors changing with time changes which really are due to other variables in the situation. 6/ For that reason the influence of forces varying with time can frequently be measured to best advantage by determining the trend in the relation, rather than the trend in each factor separately. The cotton price example (Figure 2) illustrated the way in which the trend in the level of the supplyprice curve could be determined; that is, the trend in the price which would be set by a given constant supply, rather than merely the trend in price itself. The seasonal variation in demand may similarly be determined by finding what part of the seasonal movement in price (or in consumption) cannot be accounted for by any of the other economic factors which are involved in the problem. 7/

6/ Bradford B. Smith, "The Error in Eliminating Secular Trend or Seasonal Variation before Correlating Time Series", Jour. Amer. Stat. Assoc., Vol. XX, New Series No. 152, Dec., 1925.

7/ For an example of determination of the seasonal variation in demand while simultaneously taking into account the influence of other factors, see pages 250-255 of "A Statistical Examination of Factors Related to Lamb Prices," by the present author, in Jour. Pol. Econ., Vol. XXXV, No. 2, April, 1927.

Trend lines, demand curves, and regression curves can be fitted by elaborate mathematical means. Except for demand curves it is questionable if there is usually sufficient logical basis for the selection of any particular mathematical function to represent the relation. Where a given formula is selected solely because it happens to "fit" the data fairly well, the calculated curve is still a purely empirical description of the relation, and the calculated parameters have no logical meaning.

In the case of the demand curve, however, the use of the equation

$$\text{Log}_{10}\ (\text{Price}) = a + b\ \left[\log_{10}\ (\text{supply})\right]$$

is of real value, for then the equation expresses the assumption that the elasticity of demand is constant throughout the curve. The elasticity of demand, n, may be calculated directly from the constant b, by the formula

$$n = -\frac{1}{b}$$

Where an elasticity of demand which varies at different points on the curve is assumed, this more complex relation may be considered by use of the equation

$$\text{Log}_{10}\ (\text{Price}) = a + b\ \left[\log_{10}\ (\text{supply})\right] + c\ \left[\log_{10}\ (\text{supply})\right]^2$$

Still more complex forms have been suggested by Moore, 8/ Schultz, 9/ and others.

Wherever a definite mathematical demand curve is fitted, the elasticity of demand may be measured at any point on the curve by finding the differential at that point and using Alfred Marshall's equation

$$n = -\frac{ds}{dp}\ \frac{P}{S}$$

where P represents price, and S, supply. Thus for the last equation shown,

$$n = -(b + 2\,c\,s)$$

8/ Henry Ludwell Moore, "Elasticity of Demand and Flexibility of Prices," Jour. Amer. Stat. Assoc. March, 1922.

9/ Henry Schultz, "The Statistical Law of Demand," Journal of Political Economy, Vol. XXXIII, Nos. 5 & 6, Oct. and Dec., 1925.

Except for the type of relation just discussed, it is exceedingly doubtful if the use of definite mathematical functions is of any value in price analysis work. Empirical lines or curves fitted by eye, or by semi-mechanical means such as averages or moving averages, may frequently require much less effort and may have equally as much meaning.

Other Factors Involved Besides Prices and Supplies

In the examples discussed, the treatment has been restricted to the dominant factors, and any other factors which might be concerned have been ignored. While it is generally true that for most agricultural products available supply is the dominant factor influencing market price; and that price is the dominant factor influencing consumption, storage, and subsequent production, the relation is not always so dominant as in these picked examples; other factors may be of importance; and in some cases these other factors may be of even greater importance then the price or supply factor. The remainder of this paper will therefore be devoted largely to a discussion of the other factors or elements which may be concerned in each of these relations, and a brief suggestion of the statistical devices available to take them into account in the analysis.

Factors Involved in the Relation of Price to Supply

Although ordinarily we may speak loosely of "price", when we start statistical analysis - or when we attempt to think clearly about the relation - we realize that there are multitudes of different prices, even for a single commodity such as wheat. If the different "dimensions" with respect to which the price of a given commodity may vary are enumerated, that will help to clarify the discussion. Thus prices may vary in time - and those are the variations that are usually considered in economic theory. But prices may also vary in space, as between points; they may vary between different stages of the marketing process, as at wholesale, retail, etc.; and finally, even at the same time, place, and stage of the marketing process, they may vary between different lots of the same commodity. To be perfectly definite, a given price analysis must consider the reasons for changes in prices with respect to any one of these dimensions, while holding constant the other dimensions. Thus if one investigates why the price of No. 2 red winter wheat, of 11% protein content, sold in carlots on the cash-grain floor at Kansas City, changes from day to day or week to week as it does, he will have a much more specific and clear-cut problem to deal with than if he merely asks why the price of "wheat" changes as it does - for he will be considering only the changes in price with changes in time, for a specified quality, place, and stage in marketing.

In discussing the relation of price to supply, the price at the wholesale market will usually be the one dealt with, for it is at that point that the quantity in existence and the demands for that quantity are thrown into the clearest balance. Further, the price considered will be the average price over a period of such a length as to afford time for at least a temporary equilibrium between the

supply and demand; not longer than a crop year, in the case of an annual product like cotton or potatoes, and not such a short period, as an hour or a day, to be too much influenced by temporary speculative influences, as in the central wheat markets.

In addition to the new crop, or current production in the case of a commodity produced continuously, like eggs or livestock, carry-over from the previous period, and storage stock of the partly manufactured or processed product, such as lard or hams, may also need to be considered as part of the available supply setting the price. The supply or prices of alternative or competitive products may also have some bearing on the price that will be paid for a given supply, and so need to be considered. The general level of prices will obviously affect the price. For studies which cover periods of rapidly changing monetary values, as during the inflation periods in the United States or in Germany, the index of price level may be the most important factor in explaining price changes. The particular index to use may frequently be a question difficult to answer; but the use of some index is frequently imperative. The prosperity of the consumers of the product, also, may affect prices, although for most agricultural products this influence may be much smaller than has frequently been assumed. Indexes of employment or of wage payments are more likely to be true indications of the prosperity of consumers than more sensitive business "barometers", such as pig iron production or basic industrial output. For some commodities such as wool and cotton, which enter as raw materials into industrial use, however, business activity as such may become of considerable importance. Besides these elements which have been enumerated, there are still other factors which may affect the price received for a given supply, but their influence is increasingly remote; and if the effect of the major factors can be measured, the relation of supply to price may be determined with a degree of approximation which is a fair approach to the underlying reality.

The influence of a number of different factors operating at the same time may be approximately determined by successive elimination of their effects, taking the most important factors first; or it may be more exactly determined by a simultaneous analysis by the method of multiple correlation. The simpler method was the one first employed 10/, and has given excellent results in many practical cases. The more elaborate method has given very good results in some studies, 11/ but in others has failed to yield fully satisfactory conclusions. 12/

10/ Holbrook Working, Factors Determining the Price of Potatoes in St. Paul and Minneapolis, University of Minnesota Agricultural Experiment Station, Technical Bulletin 10, 1922.

11/ Hugh B. Killough, What Makes the Price of Oats, U. S. Dept. Agri. Bul. 1351, 1925. Mordecai Ezekiel, A Statistical Examination of Factors Affecting the Price of Lamb, loc. cit.

12/ G. C. Haas and Mordecai Ezekiel, Factors Affecting the Price of Hogs, U. S. Dept. Agri. Bul. 1440, 1926.

Factors Involved in the Relation of Price to Consumption

The price which will influence consumption will obviously not be the central market price, but the price paid by the consumer, at retail or otherwise. Only to the extent that changes in the central market price are reflected to the consumer can the consumption be expected to show corresponding changes. Studies of the influence of price upon consumption can therefore be restricted to relatively small areas, taking into account the retail prices prevailing in those areas and the local consumption. In that way the demand curve may be determined for the community or area; the sum of all such curves for all areas will give the total demand curve.

In addition to the retail price, the quantity consumed may be affected by any one of the demand factors mentioned above, such as the prices of substitute or competing commodities or the purchasing power of consumers. The general level of prices may also have some influence, although here it is more likely to be the index of retail prices than of wholesale which will afford the best "price deflator".

Changes in habits, customs, or styles may affect consumption, as may advertising campaigns, temporary weather or climatic conditions, and a great variety of other factors. Only to the extent that these can be measured can their importance be determined and allowed for; sometimes their influence may be felt, and yet be beyond the reach of definite statistical measurement, except in such general and all-inclusive terms as trends or shifts in relationships. Where definite measures of these additional factors can be obtained, their influence may be measured by the same statistical devices suggested previously.

Factors Involved in the Relation of Price to Subsequent Production

In discussing the relation of supply to price and of price to consumption, it has been assumed that the prices and supplies being considered were both for the same period. Furthermore, the period considered must be sufficiently short so that the price during the early part of the period can not affect the supply during the later part, through new production coming on the market. 13/

13/ Where the period is not sufficiently short, the relation between supply and price may reflect the supply curve instead of the demand curve. The following papers discuss this possibility:

E. J. Working, What do Statistical "Demand Curves" Show?
Quart. Jour. of Econ., XLI, Feb., 1927.
Mordecai Ezekiel, Statistical Analyses and the "Laws" of Price,
Quart. Jour. of Econ., XLI, Feb. 1928.
Wossily Leontref, Ein Versuch zur statistichen Analyse Von Angebot und Nachfrage,
Weltvirstschaftliches Archiv, 30 Band, Heft 1, Juli 1929.

When the influence of price upon production is considered, however, it is necessary to relate the price in one period to the production in a subsequent period. In the case of annual crops the acreage in one year may reflect prices for two or more years past. Where the production cycle is longer, or shorter, the length of time concerned may vary correspondingly. Thus for tree crops, it may be a span of years; for hogs, one and a half to two years; for beef cattle, 7 to 8 years; and for horses, still longer. The lag will differ as to whether the number of livestock born is considered, or the number reaching market, for the time of feeding is involved as well as the period of gestation, and the time it takes producers to decide to make a change.

The price to be considered is obviously not the price which prevails on the central market, but the price received by producers. In addition to the price of the product, the prices that have been prevailing for alternative products may also influence production, such as when beef producers shift to sheep, or beef and hog farmers shift to dairying. The prices of cost factors are involved as well. Thus for hogs corn prices (in the U.S.), potato prices (in Germany), and feed prices (in Denmark) have been found to influence production quite as markedly as have hog prices. Similarly an index of dairy feed prices may be used in studying changes in milk production, or an index of poultry feed prices for egg production. Besides these purely economic factors, physical factors also may influence acreages or livestock production. Thus rainfall and temperature influence spring plantings of many crops, and the weather at birth may influence the crop of lambs, pigs, etc. Each of these possible factors must be considered and taken into account if the influence of price upon production is to be an accurate measure of the actual response to the price stimulus.

Factors Involved in the Relation of Prices at Different Stages in the Marketing Process, or at Different Places

The preceding discussion has related wholesale prices at the central markets to supply; consumption to retail prices, and subsequent production to prices paid producers. The question is still left open, then, as to why the margin between wholesale prices and retail prices may change from time to time, or between wholesale and farm (or other producer.) A special study is therefore needed of this particular problem. It is obvious that changes in labor charges, interest rates, materials (such as packaging), and similar expense items that are involved in merchandising, may affect to some extent the margin which the intermediate agencies will retain. It need not be assumed that such changes will be fully reflected in the margin - the statistical analysis can determine to what extent they are. In the case of urban marketing agencies, changes in the level of rents may temporarily tend to be reflected in the margin, even though according to economic theory the causation runs in the opposite direction. Besides these specific expense elements, the time factor must also be considered. For many staple products, a change in the wholesale price is not immediately reflected in retail prices, and only if the higher (or lower) price is continued for some time will a retail price readjustment take place. The use of a fixed lag will not wholly take this into account, for only the general trend of the wholesale price, and not all its minor fluctuations, may show up subsequently in the retail price. The influence of custom tending to hold prices constant, or to set price in even units such as 5 cent intervals may also upset or modify expected relationships.

The problem of explaining changes in the margin between prices

at different points in space is somewhat similar to the one just discussed, in that changes in expense items such as labor and transportation are involved. In addition, differences in the location of supplies may affect the prices at different points. Thus in comparing potato prices in St. Paul and in New York City, Working found that the proportion of the crop produced in the Western States and the size of the late crop both influenced the margin. 14/

Factors Involved in the Relation Between Quality and Price

One type of price analysis problem which is somewhat different in character from those which have been discussed has reference to determining why the price varies between different lots of the same commodity, sold during the same period, in the same market, and at the same stage of the marketing process. It is generally recognized, of course, that differences in quality are reflected in differences in prices; but it is only recently that attempts have been made to measure the influence of specific differences in quality on price.

The factors which will be involved here are all those physical characteristics of the product which may be measures of quality. Thus for wheat, protein content, gluten content, test weight per bushel, and proportion of dockage have all been found to influence the premium or discount per bushel; for apples, size, color, insect injuries, and amount of scab; for tomatoes, firmness, size, color, uniformity, and cracks; for asparagus, length of green color in stalk, size of stalk, and uniformity of stalks within the bunch; for cucumbers, length and slenderness; and so on for many other vegetable products. 15/ For eggs interior quality, weight, color, and cleanliness influence price per dozen. 16/

For any product, a study of this sort involves first deciding on the physical or chemical characteristics of the commodity which may influence price; working out methods for securing quantitative measures of differences in each of these factors and; then recording the price and these measures of quantity for a large enough number of individual transactions to provide an accurate basis for the necessary statistical analysis. Fortunately, the number of observations is not limited in this type of problem, and the laws of sampling apply, so it is possible to determine the true relations, even with a number of variables involved, much more accurately and dependably than in most economic studies.

Quality premiums may depend not only on the preferences of the consumers, but also on the relative supply of various qualities of the product. Thus fresh eggs do not command the premium over ordinary eggs in spring that they demand in fall when they are scarcer. The premiums paid for any particular difference in quality may themselves vary in time; and in a complete study, the

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14/ Holbrook Working, Factors Affecting the Price of Minnesota Potatoes, Univ. Agr. Expt. Sta. Tech. Bul. 29, Oct. 1925.

15/ Waugh, Frederick V. Quality as a Determinant of Vegetable Prices. Columbia Univ. Studies in Economics and Public Law. No. 312. P. S. King and Son, Ltd. London, 1929.

16/ Benner, Claude L and Gabriel, Harry G. "Marketing of Delaware Eggs, "Del. Agr. Expt. Sta. Bul. 150, 1927.

influence of changes in the composition of the supply upon the quality premiums or discounts must be considered. Thus it has been found that the premium paid for large-sized peaches, and the premium for certain varieties, changes through the season with changes in the proportions of different sizes and varieties in the supply. 17/

Forecasting Prices by Analysis Versus Forecasting by Formulae.

The previous discussion has developed means by which the influence of different factors upon prices, consumption, supplies, and premiums may be definitely evaluated. Little attention has been given to forecasting as such. It is evident that once the influence of various factors upon price has been determined, probable prices can be arrived at if those factors can be forecasted. Thus when the probable size of crop is known from crop reports, the most probable price may also be judged. In cases where producers response to price is so definite that supplies may be fairly well forecasted from past prices, and then probable prices may be forecasted from the prospective supplies, the whole process may be combined into a single equation or formulae giving the probable price to be expected from past and present conditions. 18/ Such equations have sometimes given satisfactory results for a time; but they cannot be followed blindly and without regard to changing conditions. In practice, the most dependable forecasts have been secured by combining with formal forecasting equations independent forecasts based on fundamental analysis of the economic conditions of the type described previously. 19/ In that way the empirical statement given in the equation can be logically verified by analysis in economic terms; if any of the relations seem absurd or illogical, the need of further analysis to determine the reason for the inconsistency is evident.

Forecasting in economics depends on the tendency of groups of people to react in similar ways to similar situations. They may not continue to react in the same way, so the forecast cannot achieve the exactness of physical laws; new conditions may arise or fortuitous circumstances may/set the previous reactions. Within these limits, however, quantitative analysis of why prices, supplies, and consumption have changed as they changed provides both a firmer knowledge or the realities of the situation and a better basis for judging future developments.

17/ Kantor, Harry S., Factors Affecting the Price of Peaches in the New York City Market, U. S. Dept. Agr. Tech. Bul. 115, April, 1929.

18/ For forecasting equations of this type, see Haas, G. C. and Mordecai Ezekiel, Factors Affecting the Price of Hogs, U. S. Dept. Agr. Bul. 1440, 1926, pp. 25 - 30, 46 - 51.
A. Hanan, Die Prognose der Schweinpreise, Vierteljahrshefte zur Konjunkturforschung Sonderheft 2 und 7)

19/ For a comparison of actual results by the two, see Ezekiel, Mordecai, Two methods of forecasting hog prices, Jour. Amer. Stat. Assoc., Vol. XXII, March, 1927, p. 24.